fluid, however, for they are repelled by the latter also, but they keep in a zone of weak concentration of CO_2. The chemotactic movements of Paramecium were seen also in their repulsion by strong solutions of all acids, including CO_2, by all alkaline solutions, to which category the culture fluid belonged, and to certain neutral salts and organic compounds. Towards other organic substances, e. g., sugar, glycerine, urea, Paramecia is indifferent. Tonotaxis plays no important part in the normal activities of the organism. The reason why the infusoria are not forced beyond the circumference by the electric current is that they are less strongly electrotactic than chemotactic.

The following weighty conclusion is now drawn: Since infusoria are negatively tactic to their native fluid and positively tactic to the unadvantageous CO_2, negative or positive taxis is not necessarily an adaptive movement, is not always determined by its advantage to the species.

PALÆONTOLOGY.

Archegosaurus.[1]—The results of this preliminary paper are based on the rich material of Archegosaurus contained in the "Kgl. Museum für Naturkunde" and the collection of the "Kgl. geologische Landesanstalt" in Berlin. The archegosaurs are preserved in clay-geodes, and in spliting these the bones are generally broken. After the bones had been removed with chisels or fine steel-needles, a mixture of gelatine and glycerine was poured over the plates and very good reliefs of the skeleton were thus produced.

Jäckel intends to write a monograph on Archegosaurus and gives only the more important results. He commences with the skull, and afterwards discusses the vertebral column, the limbs and the dermal skeleton.

The skull.—In the palatal region he finds some differences from the statements so far given. There exist series of teeth on the inner sides of the vomers and palatines, which show essentially the same arrangement as in the Labyrinthodontia. Larger teeth are placed between the anterior ends of the choanæ, and behind these. The choanæ are very much longer than in the Labyrinthodonts. This elongation is certainly in relation to the anterior extension of the muzzle of Archegosaurus.

[1] Jäckel, Otto. Die Organisation von Archegosaurus. Zeitschr. deutsche Geol. Ges. Jahrg., 1896, Heft 3, p. 505–521, fig. 10.

The teeth of both the inner and outer rows are separated by considerable spaces from each other and are less crowded than in the Labyrinthodonts.

The outer side of the lower jaw of *Archegosaurus decheni* is figured. It consists of four sculptured bones. Following E. Fraas,[2] he names the upper element outside of the articular face, the articular, but he doubts whether it belongs to the endoskeleton. This element is the supraangular, the angular is correctly determined, and the "infradentale" is one of the splenials.[3]

The vertebral Column.—There are said to be 25 presacral, one sacral and over one hundred caudal vertebrae. Jäckel believes that there is uncertainty about the morphology of the vertebral column of the Stegocephalia and the higher vertebrata.

Among the Rachitomi he distinguishes four elements: 1. The paired upper arches [neural arches Baur] which in Archegosaurus unite dorsally into a spinous process [neurapophysis Baur]; 2. The paired upper Pleurocentra (Interdorsalia Gadow), which are intercalated between the upper ends of the Hypocentra; 3. The paired lower Pleurocentra, *which in the tail separate themselves from the upper Pleurocentra*, (Interventralia Gadow, Hypocentra pleuralia). 4. The unpaired Hypocentrum which in the tail may split into two centres of ossifications.

First I may mention that the name *Intercentrum*, first introduced by Cope,[4] antedates Gaudry's[5] name *Hypocentrum* five years.

Cope says "The basal portions of the chevron bones are continued throughout the greater part of the Vertebral column in the Permian Genera Clepsydrops, Metarmosaurus and Epicordylus [Eryops], forming intervertebral elements to which I have given the name *intercentra*" —"The free elements of the cervical series of some reptiles are probably the same."

The name Pleurocentrum was introduced by Gaudry[6] in 1879; in the

[2] Fraas, Eberhard. Die Labyrinthodonten der Schwæbischen Trias. Palæontographica Bd. XXXVI, p. 73, Aug. 24, 1889.

[3] Baur, G. Uber die Morphologie des Unterkiefers der Reptilien. Mit 4, Abbildungen., Anat. Anz. Bd., XI, Nr. 13, Dec. 21, 1895, p. 410–415.

[4] Cope, E. D. The Homology of the Chevron Bones. AMER. NATURALIST, May, 1875, p. 319 (Published, April 22d).

[5] Gaudry, Albert. Les Enchainments du Monde Animale dans les Temps Géologiques Fossiles Primaires. Paris, 1883, p. 273, fig. 273, A. B C.

[6] Gaudry, Albert. Les Reptiles de l'époque permienne aux environs d'Autun. Bull. Soc. Géol. d. France. (3) Tome VII, 1878–1879, Paris, 1879, p. 68, and p. 65 in explanation of fig. 7.

same paper he designated, Cope's intercentrum as "Pièce inférieure du centrum." I do not believe that there has been any uncertainity about the morphology of the vertebral column of the Stegocephali and the higher Vertebrates. The whole question was definitely solved. Everybody is convinced that the pleurocentra of the Rachitomi represent the centra of the higher Vertebrates; and that the intercentra are homologous to the intercentra of the Sphenodontidæ, Geckonidæ, Uroplatidæ, Pelycosauria. These intercentra support in the tail the chevron bones, or hæmal arches; both are firmly united.

In some papers published this year by Dr. Hans Gadow[7] and Prof. Alexander Götte,[8] it is maintained, that the intercentrum of the Rachitomi forms the centrum of the Amniota; Prof. Jäckel comes to the same conclusion. Gadow and Götte have never examined any fossil Stegocephali or Pelycosauria and Jäckel, by some unfortunate calculation, has completely misunderstood the true nature of the archegosaurian vertebral column.

I shall show that this new opinion is in opposition to all morphological facts. In Archegosaurus the rib-heads are articulated below with the intercentrum, behind with the pleurocentrum and above with the pointed base of the neural arch. In the tail the lower arches (hæmapophyses, chevron bones) are united with the intercentra. In the Pelycosauria: Clepsydrops, Dimetrodon, Naosaurus, Embolophorus, Theropleura and others we have exactly the same condition. There are very well developed intercentra between the centra, which are suturally united with the neural arches. The capitulum the lower part of the rib-head is articulated to the intercentrum, the tuberculum to the anterior portion of the centrum and the base of the upper arch. In the tail the lower arches (hæmapophyses, chevron bones) are united with the intercentra.

According to Gadow, Götte, Jäckel the Intercentrum Cope, of the Rachitomi is homologous to the centrum of the Amniotia. There is no doubt, that the intercentrum plus hæmal arch (chevron) of the Pelycosauria is homologous to the intercentrum plus hæmal arch (chevron), of Archegosaurus; therefore the intercentra of the Pelycosauria are centra, according to the authors named above. Therefore, the Pelycosauria have two centra. This of course is absurd, therefore the

[7] Gadow, Hans. On the evolution of the vertebral column of Amphibia and Amniota, Philos. Trans. Roy. Soc. London, vol. 187 (1896), B. pp. 1–57. London, 1896, June 16.

[8] Götte, Alex. Ueber den Wirbelbau bei den Reptilien und einigen anderen Winbelthieren. Zeitschr, wissensch. Zool., vol. LXV, p. 343–394.

intercentra of the Rachitomi are not centra, but true intercentra, as everybody has believed so far.

We only need to examine some of the Stegocephalia in which the ossification of these elements is more advanced. In old specimens of *Eryops megacephalus* Cope, the pleurocentra are closely united to the posterior base of the neural arches; the intercentra are placed between the pleurocentra below and do not reach the neural arches. Only the first intercentrum is connected with the neural arches of the first vertebra the atlas, forming an atlas-ring as in all Amniota. How is it possible that this first intercentrum can be a centrum? The pleurocentra of Eryops are homologous to the centra of the Amniota. The rachitomous condition is the most primitive one. Before Jäckel, I described the condition in Archegosaurus as follows:[9] If we examine the vertebral column of Archegosaurus, we see that the notochord is still developed and that in the dorsal region each body of the vertebra consists of three parts, two lateral ones, the pleurocentra, and one inferior one, the intercentrum (hypocentrum). In the tail region we find even five elements; the two pleurocentra and below them two small hæmacentra Hay[10] (hypocentra pleuralia) and the intercentrum to which the hæmal arches (chevron bones) are attached."

There is very little doubt, that in the caudal vertebræ of the Rachitomi the hæmacentra, if they were present, formed with the pleurocentra a cartilaginous ring. In the precaudal region only the pleurocentra become ossified and support the neural arches. The intercentra were continued dorsad as cartilage, also forming a ring. In the tail the chevrons, lower arches, are united with them. This primitive condition is modified in two ways. First: the *intercentrum* increases in size, especially the lower portions, become broader, until they meet with each other. The *pleurocentra* become reduced, or confluent with the upper arch. The intercentra form the body of the vertebræ of the Labyrinthodontia, they are wedge-shaped, the notochord never passes through the centre, but is placed in an excavation at the upper free border of the intercentrum, or there is a small fossa at the upper posterior face of the atlas, or there may be a chordal foramen just below the upper border. From all this it is evident, that the "centra" of the *Labyrinthodontia* are *intercentra.* This opinion is now generally accepted.

[9] Baur, G. The Stegocephali. A Phylogenetic Study. With 8 Fig. Anat Anz. XI, Bd., N. 22. Mærz 20, 1896, p. 657–673.

[10] Hay, O. P. On the structure and development of the Vertebral column of *Amia.* Field Columbian Museum. Publication 5. Zoolog. Series. Vol. I, No. I, p. 40. Chicago, U. S. A. October, 1895.

The Labyrinthodonts reached a large size and became extinct at the end of the Trias.

The second modification of the rachitomous condition is seen in Cricotus Cope. Each vertebra consists of two fully ossified elements. The centra in the precaudal region completely support the neural arches, which have well-developed diapophyses. These diapophyses are placed on the neurocentral suture which is, however, completely obliterated. The centra are 15 mm. long, 25 mm. broad, and 25 mm. high; they are very deeply biconcave and notochordal. In front of this centrum is a complete intercentral disc, of the same breadth and heighth as the centrum, but only 8 mm. long; laterally at the posterior border it possesses a small process to which the capitulum of the rib is articulated. These flat intercentral discs have a very large notochordal foramen (4 mm. in diameter). In the tail the intercentral discs carry the chevrons. This condition has been called by Cope *embolomerous* and the suborder *Embolomeri*. It is evident that the *centra* are homologous to the pleurocentra. The Embolomeri became extinct in the Permian. Only two genera are known, Cricotus Cope and Diplovertebron. From the Rachitomi the Amniota developed. The pleurocentra formed the centra, and the *intercentra* were more and more reduced. Intercentra are present between all the vertebræ in the Pareiasauria (Cotylosauria) Pelycosauria, Rhynchocephalia, Geckonidæ, Uroplatidæ. In the Ichthyosauria, and Lacertilia they are confined to the anterior cervical vertebræ. In the Megalosauria, Iguanodontia, Pterosauria and Birds; the first intercentrum forms the lower piece of the atlas ring, and the second intercentrum is united with the centrum of the atlas (odontoid process) and the centre of the axis into one mass. In all mammals the first intercentrum always remains, forming the lower piece of the atlas ring, and in some mammals they are even present in the dorso-lumbo-sacral region, for instance in the Insectivora (Talpa, Erinaceus, Myogale) and in Atherura among the Rodents.[11]

I gave in 1886 a full historical account of the views on the morphogeny of the vertebral column of the Amniota from 1844, giving all the morphological, paleontological and embryological evidence.[12] Dr. Gadow certainly did not study this paper, for, after the quotation of it in his Literature, he puts in parenthesis "Extract, in German, of Cope's discoveries."

[11] Baur, G., l. c., p. 663.

[12] Baur, G. Uber die Morphogenie der Wirbelsäule der Amniolen. Biolog. Centralbl. Band VI, Nr. 11 and Nr. 12, Aug. 15, 1886, p. 322-342; 353-363.

After the discussion of the vertebral column, Jækel makes some remarks on the ribs, limb-skeleton and the dermal covering, and concludes his paper with a short summary of his results. I hope that Jækel in his final monograph on Archegosaurus will give up the absolutely unfounded opinion of the homology of the intercentrum of Archegosaurus with the centra of the higher Vertebrata.—G. B.

Reconstruction of Phenacodus primævus, the most Primitive Ungulate.[13]—This paper was accompanied by the re-mounted skeleton of Phenacodus and a wax model executed by Charles Knight. As originally mounted in Professor Cope's laboratory, the famous skeleton of *Phenacodus primævus* conveyed a very imperfect impression of its actual form and proportions. Several serious errors were committed by the restorer, the most important of which was the implanting of two of the cervical vertebræ in the tail. The author, therefore, considered it advisable to completely re-mount the animal, and this has been done by Mr. Adam Hermann and Mr. Martin, of the American Museum, at an expenditure of five months time. The animal is placed as nearly as possible in a natural position. It shows that the feet were not plantigrade, or soled upon the ground, but digitigrade, as in the tapir. The body is characterized by the great convexity of the back, characteristic of the Carnivora and of all the early ungulates. A further unguiculate feature is the great development of the hind quarters and of the tail. The disproportion between the hind and the fore quarters is heightened by the extremely small size of the head, containing a brain which was about the size of that of the opossum, as fully described by Cope.—H. F. Osborn.

BOTANY.

Observations on the Distribution of Plants Along Shore at Lake of the Woods.[1]—Professor MacMillan's paper upon the vegetation of the shores at the Lake of the Woods is the most important contribution to American phytogeography since the Metaspermæ of the Minnesota Valley of the same author. In this paper, as in the latter work, the elements of the flora have been determined with almost

[13] Read before the British Association at Toronto.

[1] MacMillan, Conway: Observations on the Distribution of Plants along Shore at Lake of the Woods. Minnesota Botanical Studies, I, 949, 1897.